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A Rescue Boat Design Utilizing Reused Plastic Bottles for Accident Prevention

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Abstract

Fiberglass layer of rescue boat has tendency to crack when hit by a heavy wave or involves in accident. As an alternative to this problem, waste plastic disposal is suggested to be reused in filling the displaced volume of the designed rescue boat. The main objective of this paper is to design a fiberglass rescue boat that has arrangement of bottles under the waterline section of the original boat design. The arrangement of waste plastic bottles will avoid the rescue boat from sinking if fiberglass layer of the boat happened to cracked.The design rescue boat will count on density and quantity of waste plastic bottles used at the core of the boat.

Keywords: rescue boat, plastic bottle, lines plan, general arrangement, ship resistance, fiberglass

1. Introduction

The Ship accident represents a major marine disaster since the historic days. Even in the age of modern ship building technology and innovative navigation equipment, ship accidents are an important area of maritime concern, including the loss of lives and huge financial implications. In the categorization of ship accident, generally we can put them in some important broad brackets based on some known causal factors- (i) Natural disasters (ii) Casualties owing to mechanical failure (iii) Navigational mistakes (iv) Operational accidents during cargo handling(v) Ignorance or human-mistakes by the crew and/or passengers (vi) Damage caused by cargo-shifting due to poor stowage. The stories of ship accident we often hear mostly pertain to fire, capsizing, collision, grounding, on-board damage owing to cargo shifting.

Production of solid waste in Malaysia is 1Kg/person per day. In average, approximately 26 million people in the country produce 26 million kilos of solid waste every single day. Plastic waste is the most common solid waste that generate in the country accounting for 7-12 percent by weight and 18-30 percent by volume of the total residential waste generated (Agarwal, 2007). Solid waste such as plastic if not disposed of properly can not only pose significant health threats but also add to visual, air and water pollution, clogging drains, water ways, breeding air borne diseases and nuisances. The need of recycling plastic waste has made an idea to reuse waste plastic bottles as one way to reduce the waste at the source because it delays or avoids its entry in the waste collection and disposal system. Fiberglass boat has tendency to crack when hit by heavy wave or involves in accident. Usually the boat sinks because of cracking on the fiberglass layer. So, the purpose to help another boat will be failed. To overcome this problem, the idea in designing a fiberglass boat that has arrangement of waste plastic bottles in the frame of rescue boat before it laminated by fiberglass, so that even when the fiberglass layer cracked the boat will remain floating. This project is about designing a fiberglass rescue boat that has arrangement of waste plastic bottles in the boat core as a way towards reducing plastic bottles disposal. The lines plan and general arrangement of the boat will be carefully designed and some theoretical analysis will be made.

2. Rescue Boat Design

2.1 Archimedes Principle

The idea of Archimedes principle states “anybody partially or completely submerged in a fluid is buoyed up by a force equal to the weight of the fluid displaced by the body” (Meredith, 2009). The weight of arrangement waste bottles acts downward, and the buoyant force provided by the displaced fluid acts upward. If these two forces are equal, the rescue boat will float even the fiberglass layer crack. Density is defined s weight per volume. If the density of an object exceeds the density of water, the object will sink.

2.2 General Features of Rescue Boat

A rescue boat is a boat rescue craft which is used to attend a vessel in distress, or its survivors, to rescue crewmen and passengers. It can be hand pulled, sail powered or powered by an engine. Rescue boats may be rigid, inflatable or rigid-inflatable combination hulled vessels. In many cases, composite boat are built by sandwiching thin fiber-reinforced skins over a lightweight but reasonably rigid core of foam, balsa wood, impregnated paper honeycomb or other material. The shape of the hull is entirely dependent upon the needs of the design. Many variables must take into accounts when selescting rescue boat. Some of the features of rescue boat are the seats are removable and can be used as floatation devices. There are also 10 handles around the outboard perimeter for carrying even in the most difficult places. The bow can be opened to allow divers to enter and exit the water safely and easily. Seating arrangements can accommodate up to 12 personnel. Swim aids, first aid kits, spot light, basic life support supplies and food storage tanker are basic features of rescue boat (Robert Rhea et al., 2010.

2.2.1 Principle Dimension of Hull

Principal of hull dimensions are:

- Length over All **(LOA)** is the extreme length from one end to the other end.
- Length at Water Line **(*Lwl*)** is the length from the forward most point ofthe waterline measured in profile to the stern-most point of the waterline.
- Length between Perpendicular **(*Lpp*)** is the length of the summer load waterline from the stern post to the point where it crosses the stem, ***Lpp*** is the length between foremost perpendicular usually a vertical line through the stem's intersection with the waterline, and aft most perpendicular which, normally, coincides with the rudder axis (Harvald, 1983).

$$Lpp = 0.97xLwl$$

- Beam or breadth **(*Bwl*)** is the width of the hull on waterline.
- Draught**(D)** is the vertical distance measured from the bottom of the hull to the waterline.

2.2.2 Coefficient used in Hull Construction

- Block coefficient, ***Cb***

Various form coefficients are used to express the shape of the hull. The most important of these coefficient *Cb*, which is defined as the ratio between the displacement volume V and the volume of a box with dimensions $\boldsymbol{Lwlx\ \ Bwl\ \ x\,D}$ (Harvald, 1983).

$$Cb = \frac{V}{LwlxBwlxD}$$

However, shipbuilder often used Cb,pp, based on Length Between Perpendicular, ***Lpp***, in which case the Cb will, as a rule, be slightly larger, because, as previously mentioned, ***Lpp*** is normally slightly less than $\boldsymbol{Lwl}$.

$$Cb,pp = \frac{V}{LppxBwlxD}$$

- Water plane area coefficient, ***Cwl***

The water plane area coefficient ***Cwl*** expresses the ratio between the vessel's waterline area Awl and the product of the length Lwl and the breadth $\boldsymbol{Bwl}$ of the ship on the waterline:

$$Cwl = \frac{Awl}{LwlxBwl}$$

Generally, the water plane area coefficient is some 0.10 higher than the block coefficient:

$$Cwl \approx Cb + 0.10$$

This difference will be slightly larger on fast vessels with small block coefficients where the stern is also partly immersed in the water and thus becomes part of the "water plane" area (Harvald, 1983).

- Midship section coefficient, ***Cm***

A further description of the hull form is provided by the midship section coefficient ***Cm***, which expresses the ratio between the immersed midship section area ***Am*** (midway between the foremost and the aft most perpendiculars) and the product of the ship's breadth ***Bwl***and draught ***D*** (Harvald, 1983).

$$Cm = \frac{Am}{BwlxD}$$

- Longitudinal prismatic coefficient, ***Cp***

The longitudinal prismatic coefficient ***Cp***expresses the ratio between displacement volume V and the product of the midship frame section area ***Am*** and the length of waterline (Harvald, 1983).

$$Cp = \frac{V}{AmxLwl} = \frac{V}{CmxBwlxDxLwl} = \frac{Cb}{Cm}$$

As can be seen, ***Cp*** is not an independent form coefficient, but is entirely dependent on the block coefficient ***Cb***and the midship section coefficient ***Cm***.

- Longitudinal Centre of Buoyancy, ***LCB***

LCB expresses the position of the centre of buoyancy and is defined as the distance between the centre of buoyancy and the midpoint between the ship's foremost and aft most perpendiculars. The distance is normally stated as a percentage of the length between the perpendiculars and is positive if the centre of buoyancy is located to the fore of the mid-point. For a ship designed for high speeds, will normally be negative whereas for slow speed it will normally be positive.The ***LCB*** is generally between -3% and +3% (Harvald, 1983).

2.2.3 Ship Resistance

To move a ship, it is first necessary to overcome resistance that is the force working against its propulsion. The calculation of resistance R plays a significant role in the selection of the correct propeller and in the subsequent choice of main engine. Generally, a ship's resistance is particularly influenced by its speed, displacement and hull form. The total resistance RT, concist of much source resistance R which can be divided into 3 main groups: Frictional resistance, Residual resistance and Air resistance.

- Frictional resistance, ***Rf***

The frictional resistance ***Rf*** of the hull depends on the size of the hull's wetted area As, and on the specific frictional resistance coefficient **Cf.** The friction increase with fouling of the hull, in example by growth of algae, sea grass and barnacles. When the ship is propelled through the water; the frictional resistance increases at a rate that is virtually equal to the square of the vessel's speed (Harvald, 1983). The frictional resistance is found as follows:

$$Rf = Cf \ x \ K$$

- Residual resistance, ***Rr***

Residual resistance ***Rr*** comprises wave resistance and eddy resistance. Wave resistance refers to the energy loss caused by waves created by the vessel during its propulsion through the water, while eddy resistance refers to the loss caused by flow separation which creates eddies, particularly at the aft end of the ship. The residual resistance normally represents 8-25 % of the total resistance for low speed ships, and up to 40-60 % for high speed ships (Harvald, 1983). The procedure for calculating the specific residual resistance coefficient ***Cr*** and the residual resistance is found as follow:

$$Rr = Cr + K$$

- Air resistance, ***Ra***

In calm weather, air resistance is, in principle, proportional to the square of the ship's speed, and proportional to the cross-sectional area of the ship above the waterline. Air resistance normally represents about 2% of the total resistance. The air resistance can be similar to the foregoing resistances that can be expressed as Ra = Ca + K , but is sometimes based on 90% of the dynamic pressure of air with a speed of V(Sv. Aa. Harvald, 1983):

$$Ra = 0.90 \ x^{1/2} \ x \ \rho air \ x \ V^2 \ x \ Aair$$

Where ρair is the density of the air, A_{air} and is the cross-sectional area of the vessel above the water.

- Total resistance, ***(RT)***

The ship's total towing resistance **RT** is thus found as:

$$RT = Rf + Rr + Ra$$

3. Design Drawing

Lines Plan

The lines plans of a boat provide an immediate indication of its looks, performance, and sea-worthiness. They typically consist of three perpendicular views of the hull: the profile, or sheer plan, is the view from one side; the half-breadth plan is the view from directly above; and the body plan consists of views from directly in front of and behind the boat.

General Arrangement

The general arrangement is a naval architecture drawing showing the inside of a ship and where the main elements are placed. This drawing shows overall views of the equipment and provides all of the information to produce transportation, layout and installation drawings. It includes a list of the arrangement drawing such as dimensions, installation details, overall weight or mass, weight of subsystem and service supply details.

Waste plastic Bottles Properties

Waste plastic bottles dimension was showed in Figure 1. Mass for dried waste plastic bottles is 39.69 grams.

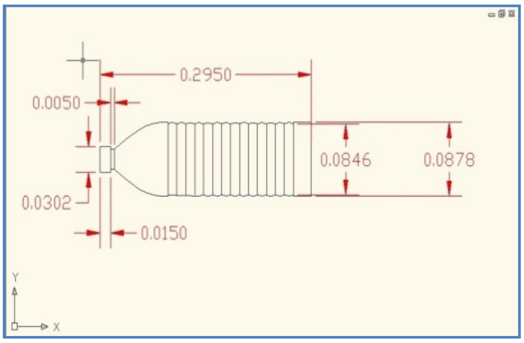

Figure 1. Dimensions of waste plastic bottles

4. Results and Discussions

The design of the rescue boat body was drawn in the DELFT SHIP MARINE software. It is to visualize the design dimension before designing the lines plan of the rescue boat.

A. Design Dimension of the Rescue Boat

Tables 1 shows the dimension of designed rescue boat.

Table 1. Dimension of rescue boat

Parameter	Value
Length Overall, LOA	6.000 m
Length between perpendicular, LPP	4.692 m
Length of waterline, LWL	4.837 m
Breadth, B	1.400 m
Breadth on waterline, BWL	1.177 m
Draft, D	0.250 m
Speed, V	20 Knots

B. Design of Rescue Boat Body

Figure 2 shows the design of the preliminary body of the rescue boat further design using waste plastic bottles. It is based on the design dimension showed in Table 1. The drawing applied orthographic projection.

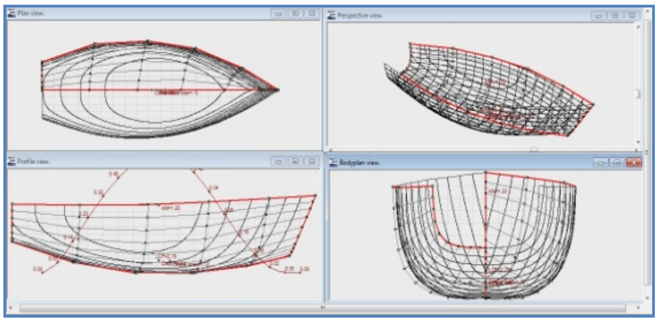

Figure 2. Preliminary design of rescue boat body

C. Hydrostatic Analysis

Hydrostatic analysis of the design was analyzed by DELFT SHIP MARINE software based on the design dimension of the rescue boat. From the coefficient listed in Table 2, the entire coefficients are in the range of standard size rescue boat.

Table 2. List of coefficient of rescue boat

Coefficient	Value
Block Coefficient, Cb	0.2441
Midship Coefficient, Cm	0.5760
Prismatic Coefficient, Cp	0.4239
Waterline Coefficient, Cw	0.4400

Table 3. Volume properties of rescue boat

Volume Properties	Value
Moulded Volume	1.128 m^3
Total Displaced Volume	1.123 m^3
Displacement	1156 kg
Wetted Surface Area	6.543 m^3
Longitudinal Center of Buoyancy	2.899 m
Vertical Center of Buoyancy	0.229 m

Table 3 shows the displacement of the rescue boat is 1156 kg. The designed the rescue boat estimated to carry 6 persons of victim that have an average weight of 100kg. The designed arrangement of waste plastic bottles will be in the moulded volume.

Table 4. Waterplane properties of rescue boat

Waterplane Properties	Value
Length on Waterline (m)	4.803
Beam on Waterline (m^3)	1.749
Entrance Angle (deg)	13.381
Waterplane Area (m^2)	5.808
Waterplane Center floatation (m)	2.784

The design of waste plastic bottles arrangement in the lines plan will be under waterline surface. Table 4 listed all the waterplane properties of the designed rescue boat.

D. Lines Plan Design

The lines plan design of the rescue boat (see in Figure 3) was drawn in AutoCAD 2009 software based on the design created in the DELFT SHIP MARINE software previously (Delfship, 2010). The lines plan of the rescue boat will include the arrangement of waste plastic bottles in displaced volume of rescue boat on water in body plan, sheer plan and half breadth plan.

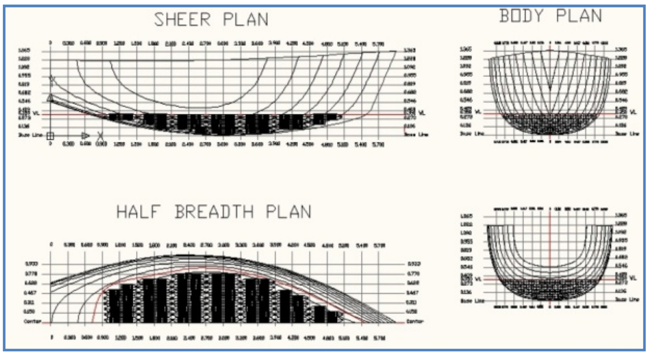

Figure 3. Lines plan rescue boat designed

The lines plan design used to calculate the total mass of waste plastic bottles been used in the design. Vertically, the arrangement of waste plastic bottles has four layers. This four layers are used as a base point to calculate the total mass in the arrangement.

Table 5. Mass analysis of waste plastic bottles

Layer	Mass of Bottle (kg)	Total Bottle	Total Mass (kg)
Layer 1	0.03969	127	5.04063
Layer 2	0.03969	89	3.53241
Layer 3	0.03969	56	2.22264
Layer 4	0.03969	31	1.23039
Total		303	12.02607

Table 5 shows the total quantity of waste plastic bottles, its need to be used for the design is 303 bottles. The total mass is 12.02607 kg. As mentioned earlier, the total number of people on the rescue boat at one time is 6 peoples of an average 100kg. It shows the design of waste plastic bottles arrangement not exceeding the total displacement of the rescue boat which is 1156 kg. Thus, the arrangement of waste plastic bottles will save the boat from sinking when the fiberglass layer cracks.

General Arrangement

Figure 4 shows the details arrangement of the rescue boat. The rescue has 6 seats, 1 engine space and 1 storage tanker for rescue. The storage tanker is designed to store some foods, first aid kit, medicine, torchlight, compass and other relevant things.

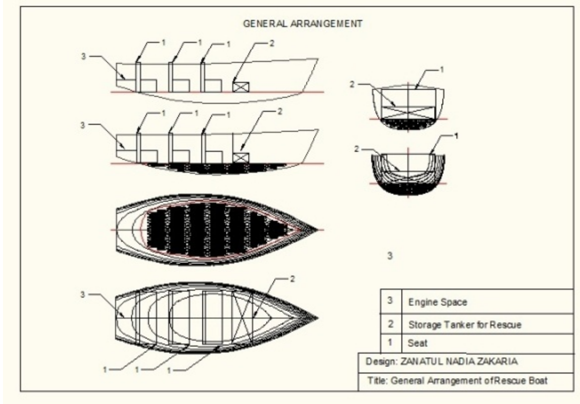

Figure 4. General arrangement of rescue boat

5. Conclusion

Designing a boat, that has arrangement of waste plastic bottles in the frame of rescue boat before it laminated by fiberglass, therefore even when the fiberglass layer cracked the boat will remain floating.

Preliminary design of fiberglass rescue boat using waste plastic bottles has been done.Waste plastic bottles with 1.5L volume that normally used as mineral water containers are used in this design. The arrangement of waste plastic bottles was designed at filling the volume displaced by the original designed of the rescue boat. The lines plan and general arrangement drawing of the rescue boat has been filled with waste plastic arrangement by considering the critical point that when boat fiberglass cracks it usually happened under the waterline surface section. While this is only a preliminary design, detail design will be the next important step before actual final fabrication of the fiberglass rescue boat can be fully executed.

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